Section 2

How Soil Forms

Reading Preview

Key Concepts

- What is soil made of and how does it form?
- How do scientists classify soils?
- What is the role of plants and animals in soil formation?

Key Terms

- soil
- bedrock
- humus
- fertility
- loam
- soil horizon
- topsoil
- subsoil
- litter
- decomposer

Target Reading Skill

Building Vocabulary A definition states the meaning of a word or phrase by telling about its most important feature or function. Carefully read the definition of each Key Term and also read the neighboring sentences. Then write a definition of each Key Term in your own words.

Lab zone **Discover Activity**

What Is Soil?

1. Use a toothpick to separate a sample of soil into individual particles. With a hand lens, try to identify the different types of particles in the sample. Wash your hands when you are finished.
2. Write a "recipe" for the sample of soil, naming each of the "ingredients" that you think the soil contains. Include what percentage of each ingredient would be needed to make up the soil.
3. Compare your recipe with those of your classmates.

Think It Over

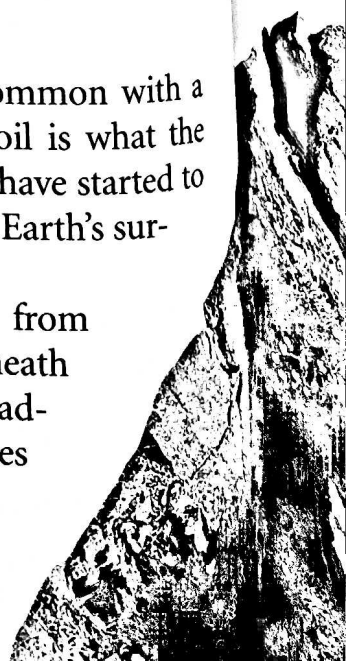
Forming Operational Definitions Based on your observations, how would you define *soil*?

A bare rock surface does not look like a spot where a plant could grow. But look more closely. In that hard surface is a small crack. Over many years, mechanical and chemical weathering will slowly enlarge the crack. Rain and wind will bring bits of weathered rock, dust, and dry leaves. The wind also may carry tiny seeds. With enough moisture, a seed will sprout and take root. Then, a few months later, the plant blossoms.

What Is Soil?

The crack in the rock seems to have little in common with a flower garden containing thick, rich soil. But soil is what the weathered rock and other materials in the crack have started to become. **Soil** is the loose, weathered material on Earth's surface in which plants can grow.

One of the main ingredients of soil comes from bedrock. **Bedrock** is the solid layer of rock beneath the soil. Once exposed at the surface, bedrock gradually weathers into smaller and smaller particles that are the basic material of soil.



Soil Composition Soil is more than just particles of weathered bedrock. **Soil is a mixture of rock particles, minerals, decayed organic material, water, and air.** Together, sand, silt, and clay make up the portion of soil that comes from weathered rock.

The decayed organic material in soil is called humus. **Humus** (HYOO mus) is a dark-colored substance that forms as plant and animal remains decay. Humus helps create spaces in soil for the air and water that plants must have. Humus also contains substances called nutrients, including nitrogen, sulfur, phosphorus, and potassium. Plants need nutrients in order to grow. As plants grow, they absorb nutrients from the soil.

Fertile soil is rich in the nutrients that plants need to grow. The **fertility** of soil is a measure of how well the soil supports plant growth. Soil that is rich in humus has high fertility. Sandy soil containing little humus has low fertility.

Soil Texture Sand feels coarse and grainy, but clay feels smooth and silky. These differences are differences in texture. Soil texture depends on the size of individual soil particles.

The particles of rock in soil are classified by size. As you can see in Figure 7, the largest soil particles are gravel. The smallest soil particles are clay. Clay particles are smaller than the period at the end of this sentence.

Soil texture is important for plant growth. Soil that is mostly clay has a dense, heavy texture. Some clay soils hold a lot of water, so plants grown in them may "drown" for lack of air. In contrast, sandy soil has a coarse texture. Water quickly drains through it, so plants may die for lack of water.

Soil that is made up of about equal parts of clay, sand, and silt is called **loam.** It has a crumbly texture that holds both air and water. Loam is best for growing most types of plants.

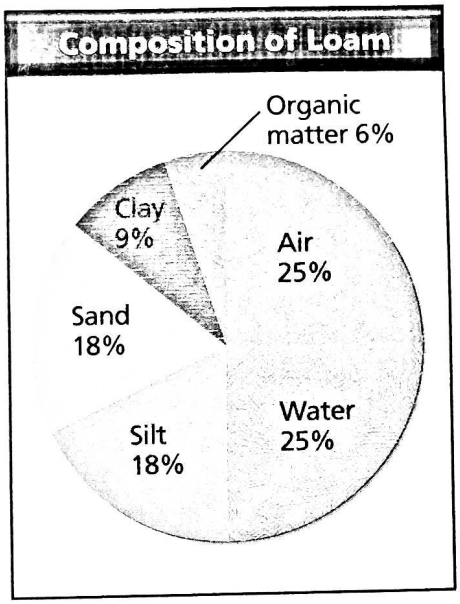
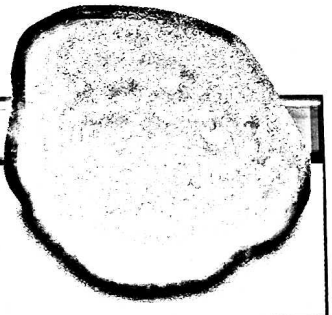


FIGURE 6
Loam, a type of soil, is made up of air, water, and organic matter as well as materials from weathered rock. **Interpreting Graphs** *What two materials make up the major portion of this soil?*

FIGURE 7
Soil particles range in size from gravel to clay particles too small to be seen by the unaided eye. The sand, silt, and clay shown here have been enlarged.

Soil Particle Size



Clay	Silt	Sand	Gravel
Less than $\frac{1}{256}$ mm	Less than $\frac{1}{16}$ mm	Less than 2 mm	2 mm and larger

The Process of Soil Formation

Soil forms as rock is broken down by weathering and mixes with other materials on the surface. Soil is constantly being formed wherever bedrock is exposed. Soil formation continues over a long period of time.

Gradually, soil develops layers called horizons. A **soil horizon** is a layer of soil that differs in color and texture from the layers above or below it.

If you dug a hole in the ground about half a meter deep, you would see the different soil horizons. Figure 8 shows how soil scientists classify the soil into three horizons. The A horizon is made up of **topsoil,** a crumbly, dark brown soil that is a mixture of humus, clay, and other minerals. The B horizon, often called **subsoil,** usually consists of clay and other particles washed down from the A horizon, but little humus. The C horizon contains only partly weathered rock.

The rate at which soil forms depends on the climate and type of rock. Remember that weathering occurs most rapidly in areas with a warm, rainy climate. As a result, soil develops more quickly in these areas. In contrast, weathering and soil formation take place slowly in areas where the climate is cold and dry.

Some types of rock weather and form soil faster than others. For example, limestone, a type of rock formed from the shells and skeletons of once-living things, weathers faster than granite. Thus, soil forms more quickly from limestone than from granite.

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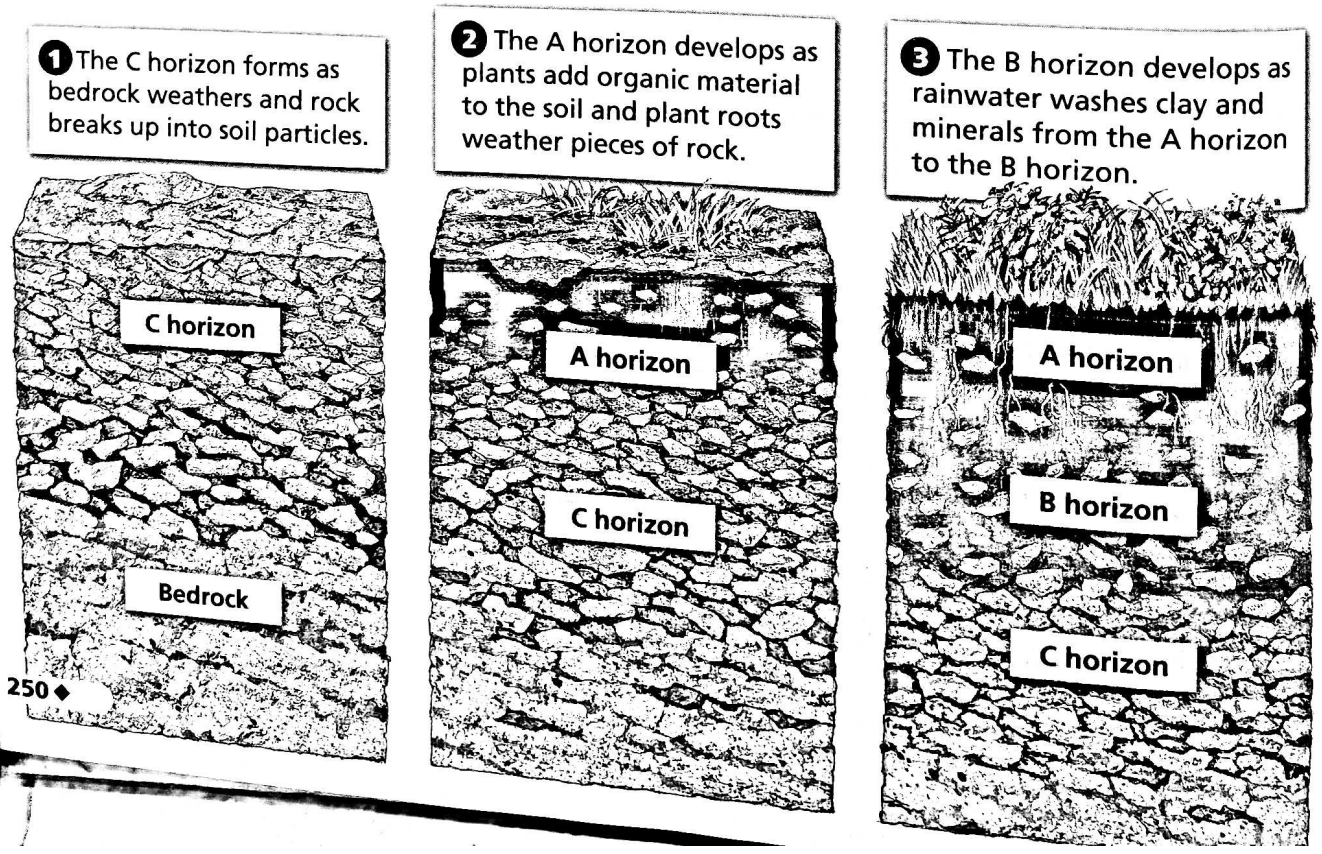
FIGURE 8
Soil Layers
Soil horizons form in three steps. Inferring *Which soil horizon is responsible for soil's fertility? Explain.*



Tundra soils	Form where it is cold year-round; thin soil with little humus.
Northern forest soils	Form in cool, wet climates; range from thick and fertile to thin with little humus.
Prairie soils	Form in cool, dry climates; topsoil thick and rich in humus.
Mountain soils	Topsoil often thin because cold temperatures slow chemical weathering and erosion causes soil loss.
Southern forest soils	Form in warm, wet climates; may be low in humus.
Desert soils	Form in dry areas with few plants and little chemical weathering; often sandy, thin soil that is low in humus.
Tropical soils	Form in wet, tropical climates; often low in humus and minerals.

FIGURE 9
An area's climate and plant life help to determine what type of soil forms from bedrock. **Interpreting Maps** *In which part of the United States are tundra soils found?*

Soil Types

If you were traveling across the hills of north-central Georgia, you would see soils that seem to be made of red clay. In other parts of the country, soils can be black, brown, yellow, or gray. In the United States alone, there are thousands of different types of soil.

Scientists classify the different types of soil into major groups based on climate, plants, and soil composition. Fertile soil can form in regions with hot, wet climates, but rain may wash humus and minerals out of the A horizon. In mountains and polar regions with cold, dry climates, the soil is often very thin. The thickest, most fertile soil forms in climate regions with moderate temperatures and rainfall.

The most common plants found in a region are also used to help classify the soil. For example, grassland soils are very different from forest soils. In addition, scientists classify soil by its composition—whether it is rocky, sandy, or rich in clay. Other factors in the classification of soil include the type of bedrock and the amount of time the soil has been developing.

Major soil types found in North America include forest, prairie, desert, mountain, tundra, and tropical soils. Look at Figure 9 to see where each of the major soil types is found.

Reading Checkpoint **What major soil types are found in North America?**

Lab zone Try This Activity

A Square Meter of Soil

1. Outdoors, measure an area of one square meter. Mark your square with string.
2. Observe the color and texture of the soil at the surface and a few centimeters below the surface. Is it dry or moist? Does it contain sand, clay, or gravel? Are there plants, animals, or humus?
3. When you finish, leave the soil as you found it. Wash your hands.

Drawing Conclusions What can you conclude about the soil's fertility? Explain.

Living Organisms in Soil

If you look closely at soil, you can see that it is teeming with living things. **Some soil organisms make humus, the material that makes soil fertile. Other soil organisms mix the soil and make spaces in it for air and water.**

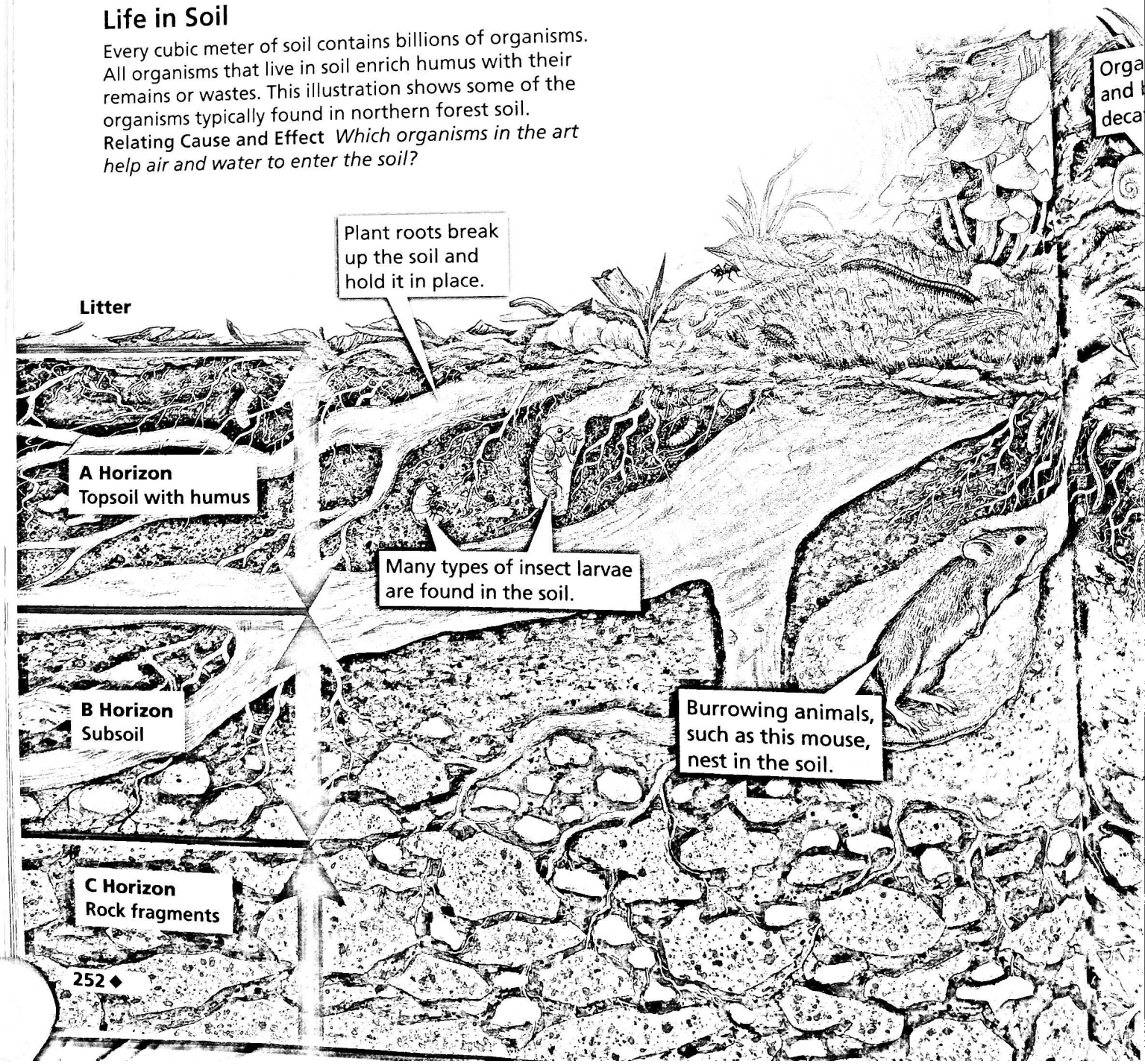
Forming Humus Plants contribute most of the organic remains that form humus. As plants shed leaves, they form a loose layer called **litter.** When plants die, their remains fall to the ground and become part of the litter. Plant roots also die and begin to decay underground. Although plant remains are full of stored nutrients, they are not yet humus.

FIGURE 10

Life in Soil

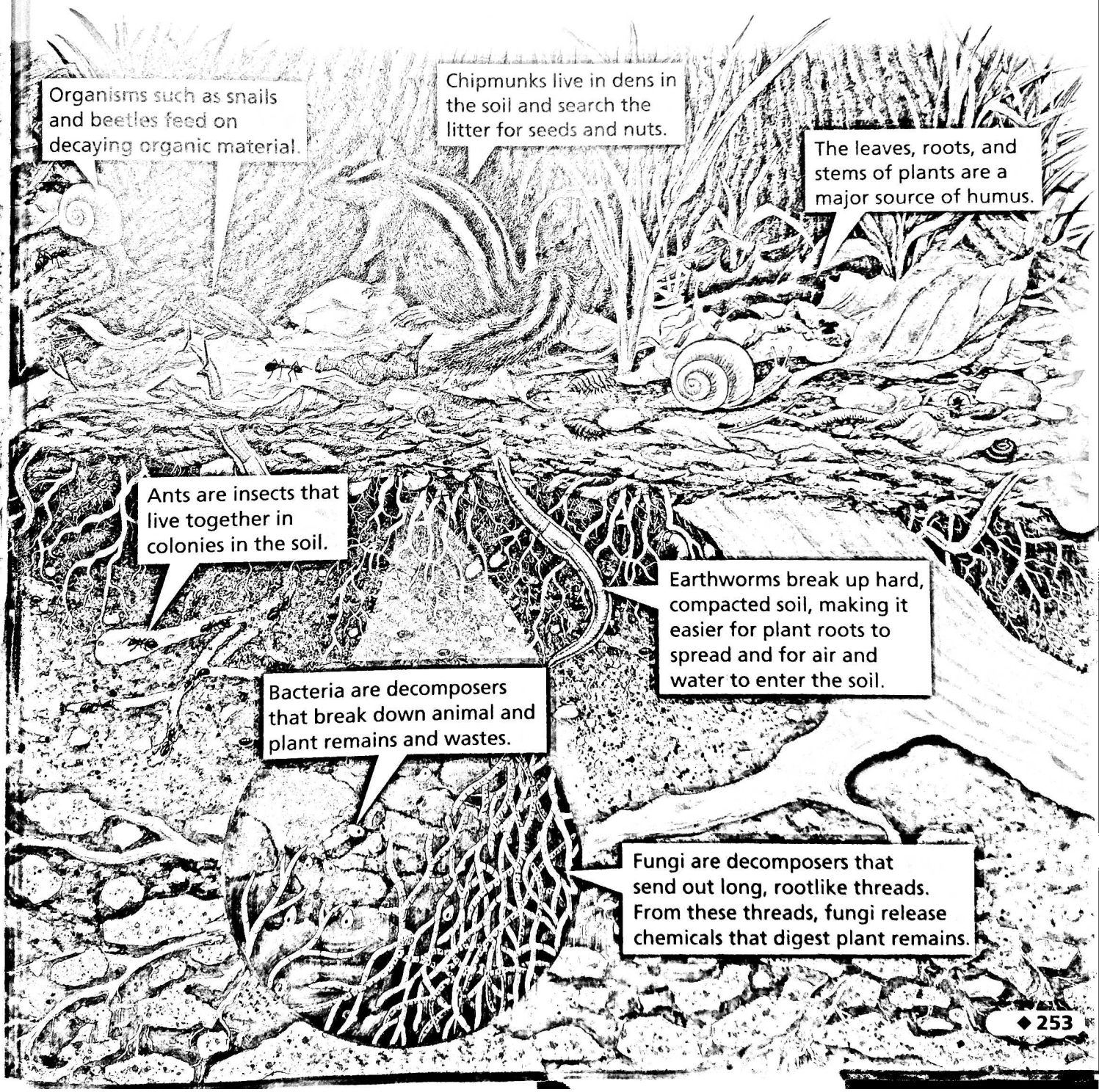
Every cubic meter of soil contains billions of organisms. All organisms that live in soil enrich humus with their remains or wastes. This illustration shows some of the organisms typically found in northern forest soil.

Relating Cause and Effect *Which organisms in the art help air and water to enter the soil?*



Humus forms in a process called decomposition. During decomposition, organisms that live in soil turn dead organic material into humus. These organisms are called decomposers. **Decomposers** are the organisms that break the remains of dead organisms into smaller pieces and digest them with chemicals.

Soil decomposers include fungi, bacteria, worms, and other organisms. Fungi are organisms such as molds and mushrooms. Fungi grow on, and digest, plant remains. Bacteria are microscopic decomposers that cause decay. Bacteria attack dead organisms and their wastes in soil. Very small animals, such as mites and worms, also decompose dead organic material and mix it with the soil.



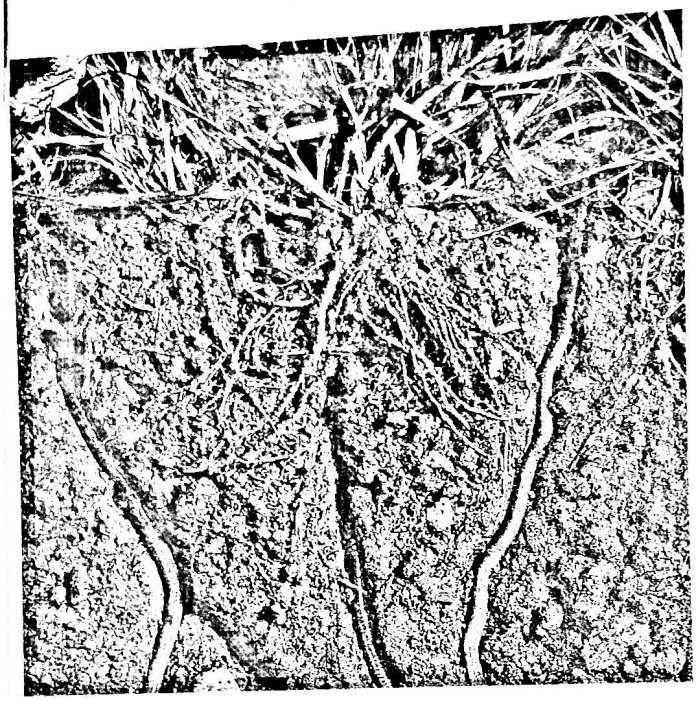


FIGURE 11
Soil Mixers
Earthworms break up the soil, allowing in air and water. An earthworm eats its own weight in soil every day. **Predicting** *How fertile is soil that contains many earthworms likely to be? Explain.*

Mixing the Soil Earthworms do most of the work of mixing humus with other materials in soil. As earthworms eat their way through the soil, they carry humus down to the subsoil and subsoil up to the surface. Earthworms also pass out the soil they eat as waste. The waste soil is enriched with substances that plants need to grow, such as nitrogen.

Many burrowing mammals such as mice, moles, prairie dogs, and gophers break up hard, compacted soil and mix humus through it. These animals also add nitrogen to the soil when they produce waste. They add organic material when they die and decay.

Earthworms and burrowing animals also help to aerate, or mix air into, the soil. Plant roots need the oxygen that this process adds to the soil.

Reading Checkpoint **Which animals are most important in mixing humus into the soil?**

Section 2 Assessment

Target Reading Skill

Building Vocabulary Use your definitions to help you answer the questions below.

Reviewing Key Concepts

1. **a. Describing** What five materials make up soil?
   b. Explaining How do soil horizons form?
   c. Sequencing Place these terms in the correct order starting from the surface: C horizon, subsoil, bedrock, topsoil.
2. **a. Reviewing** What are three main factors used to classify soils?
   b. Interpreting Maps Soil forms more rapidly in warm, wet areas than in cold, dry areas. Study the map in Figure 9. Which soil type on the map would you expect to form most slowly? Explain.
3. **a. Identifying** What are two main ways in which soil organisms contribute to soil formation?
   b. Describing Give examples of three types of decomposers and describe their effects on soil.
   c. Predicting What would happen to the fertility of a soil if all decomposers were removed? Explain.

Writing in Science

Product Label Write a product label for a bag of topsoil. Your label should give the soil a name that will make consumers want to buy it, state how and where the soil formed, give its composition, and suggest how it can be used.